Pore-scale simulation of fuid flow and solute dispersion in three-dimensional porous media

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Pore-scale simulation of fuid flow and solute dispersion in three-dimensional porous media

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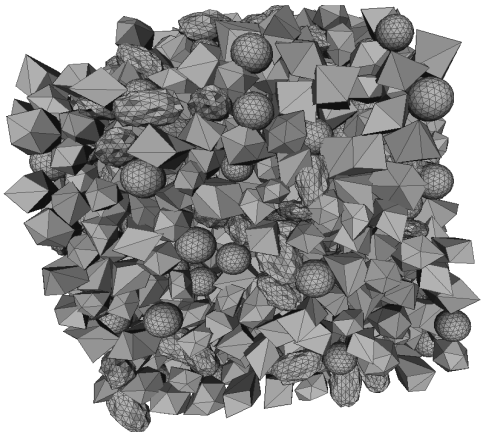
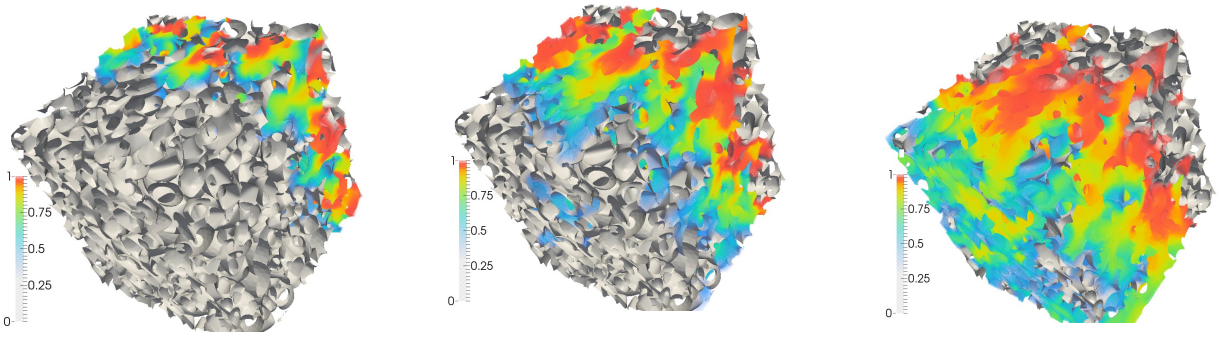
In the present work fluid flow and solute transport through porous media are described by solving the governing equations at the pore-scale with finite-volume discretization. Instead of solving the simplified Stokes equation (very often employed in this context) the full Navier-Stokes equation is used here. Realistic three-dimensional porous media are created in this work by packing together, with standard ballistic physics, irregular and polydisperse objects. An example of such packings, obtained with the open-source code Blender, is reported in the figure on the left.



Great attention is paid to numerical issues related to mesh generation and spatial discretization, which play an important role in determining the final accuracy of the finite-volume scheme, and are often overlooked. Mesh generation, fluid flow and solute transport are simulated with the open-source computational fluid dynamics code openFoam.
The calculations performed include steady-state flow simulations and transient solute dispersion simulations, as clearly depicted in the figure below.



Results are then analyzed in terms of velocity distributions and dispersion rates in a wider range of operating conditions, when compared with other works carried out by solving the Stokes equation. Results show that dispersion within the analyzed porous medium is adequately described by classical power laws obtained by analytic homogenization. Eventually the validity of Fickian diffusion to treat dispersion in porous media is also assessed.